

On the Relationship of Resistivity to Arsenic Concentration for Heavily Doped n-type Silicon

Since the energy band structure of heavily doped silicon is not well understood, neither the Fermi level nor mobility can be calculated accurately. Thus, the electrically active impurity profile is very difficult to obtain either from measurements or calculations. However, for As-doped n-type silicon, the total As concentration profile (the total concentration of both electrically active and inactive As) can be measured by neutron activation analysis. The sheet resistivity, an important parameter in controlling diffusion, can then be calculated from the total As concentration profile by means of the equation

$$\rho_s(\text{ohm}) = \left\{ \int_0^{x_j} [\rho(x)]^{-1} dx \right\}^{-1}, \quad (1)$$

where $\rho(x)$ is the resistivity (ohm-cm), x_j is the junction depth, and $x = 0$ is the location of the silicon surface, if an accurate curve for resistivity vs total As concentration is available.

Since Irvin's curve [1] is based on measurement data for impurity concentrations below $2 \times 10^{20} \text{ cm}^{-3}$ and is not entirely reliable for values higher than 10^{20} , it cannot be used for this purpose. This letter presents some preliminary results of an effort to determine the accurate relationship for the higher concentrations.

It is known that the sheet resistivity at depth x from the surface is defined as

$$\rho_s(x) = \left\{ \int_x^{x_j} [\rho(y)]^{-1} dy \right\}^{-1}. \quad (2)$$

From Eq. (2), the following relationship can be obtained:

$$\frac{1}{\rho(x)} = -\frac{d}{dx} \left[\frac{1}{\rho_s(x)} \right]. \quad (3)$$

From Eq. (3), the resistivity profile can be obtained from the sheet resistivity profile $\rho_s(x)$ vs x . By comparing that profile with the corresponding total As concentration profile, N_{total} vs x , obtained by neutron activation analysis, the resistivity vs total As concentration curve can be obtained.

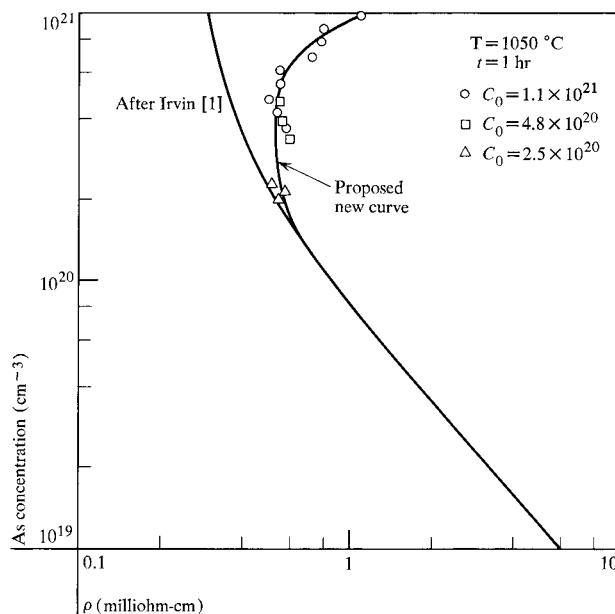


Figure 1 Resistivity vs arsenic concentration for concentrations between 10^{19} and 10^{21} cm^{-3} .

The curve shown in Fig. 1 has been obtained from the analysis of numerous arsenic diffusion profiles obtained by neutron activation analysis with corresponding differential sheet resistance profiles. Calculated sheet resistivity based on this curve is generally in good agreement with the measured sheet resistivity for As concentrations below 10^{21} cm^{-3} , as shown in Figs. 7(a), 8 and 9 of Ref. [2].

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References

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2. T. L. Chiu and H. N. Ghosh, "A Diffusion Model for Arsenic in Silicon," *IBM J. Res. Develop.* **15**, 472 (1971, this issue).

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